

ORIGINAL

The Effect of Limiting Tapioca Milk Tea on Added Sugar Consumption In Taiwanese Young Male and Female Subjects

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Abstract : Tapioca milk tea, the most popular beverage in Taiwan, is consumed a lot by Taiwanese which contributed to their daily sugar intake. Our study purpose is to investigate whether limiting intake of tapioca milk tea is useful for the control of sugar intake in Taiwanese. The study was conducted in questionnaires selected 38 subjects, 20-24 y, from 341 university students in Kaohsiung City, Taiwan. Subjects were match-paired by sex, age, department, and randomly divided into two groups for cross-over design in which each group had 1 week with or without tapioca milk tea. Other beverages and foods were allowed freely in both periods. Each group member recorded their own daily sugary intake for two weeks and was confirmed by researchers the next day. The average sugar intakes with or without tapioca milk tea were similar between the two treatments ($p > 0.05$), 58.4 ± 23.2 g/day and 56.5 ± 22.2 g/day (glucose 25%, fructose 19%, sucrose 53%, lactose 3%). With or without tapioca milk tea, 85% of sugar intakes came from beverages. Even by limiting tapioca milk tea, the subjects took the same sugar amount from other beverages, suggesting that an established sugar intake level is hard to change. *J. Med. Invest.* 65 : 43-49, February, 2018

Keywords : sugar intake, tapioca milk tea, food habit, Taiwan

INTRODUCTION

Sugar-sweetened beverages, especially tapioca milk tea, are very popular in Taiwan. Beverages stores are everywhere ; according to the statistics from the Ministry of Finance in Taiwan, there are about 16,000 beverage stalls in Taiwan(1). Beverage production value grew from NT \$ 30.4 billion in 2010 to NT \$ 51.9 billion in 2014(1).

According to the Nutrition and Health Survey in Taiwan (NAHSIT) over the years, the average daily energy intakes from sugar-sweetened beverages in adults were 141 kcal, high school students 200 kcal, junior high school students 156 kcal, and elementary school children 119 kcal(2), which were from 5 to 8% of total energy intake. However, there have been no reports about sugar compositions (glucose, fructose, sucrose, lactose, maltose).

Sugar-sweetened beverages, especially tapioca milk tea, are very popular in Taiwan. Regular size is 700 mL and 550 kcal(3). According to the Dietary Guidelines for Taiwanese 2013, the energy recommendation for a 19-30 year-old male (average height and weight 171 cm and 64 kg, respectively) is 2400 kcal per day(4). A cup of tapioca milk tea, accounts for 22 percent of total energy intake, equivalent to about two bowls of rice.

There are many reports about the high intake of sweetened beverages in students in elementary schools, junior and senior high schools and universities in Taiwan. However, only one study on 2-5-year old children is available on the quantity (5).

Beverages often contain high isomerized sugar made from starch.

In the US, isomerized sugar is usually made from corn starch and is called high-fructose corn syrup (HFCS). It is soluble and usually used in sugar-sweetened beverages. Because high-fructose corn syrup is cheaper and sweeter than sucrose, it is widely used in beverages, frozen fruit, candy, jelly, and dairy products. In recent years, there are reports that high-fructose corn syrup can lead to many health problems(6-18). For example, fructose elevates blood triglyceride concentrations more than glucose (8-11), increases body weight and causes obesity(6-8, 12-16), which induces insulin resistance and diabetes(16-18).

Because sugar-sweetened beverages pose a health threat, former US President Bill Clinton proposed a plan to stop the sale of cola and other sugar-sweetened beverages in public elementary schools(19). However, it is unknown whether limiting tapioca milk tea in Taiwan is effective in reducing sugar intake. There was no literature about sugar intake from sugar-sweetened beverages and sweet snacks in university students. Therefore, the aim of the study was to elucidate whether limiting tapioca milk tea could reduce sugar intake in university students.

METHODS

Subjects

The necessary sample size was calculated by following equation : $n > [\sigma / \mu \times 0.05]^2 = [18 / (60 \times 0.05)]^2 = 36$

Where n = number of subjects, σ = standard deviation, μ = average value

In addition, allowing for a 10% drop-out rate, the necessary sample size was 40. The study was conducted in summer with about 38 university students of 20 to 24 years old from southern Taiwan. First, we collected 341 questionnaires from university students to assess university students for their preference for

Received for publication September 8, 2017 ; accepted October 16, 2017.

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sugar-sweetened beverages and sweet snacks. Subjects in this study were selected from those who favored sugar-sweetened beverages and sweet snacks. We designed this questionnaire to select appropriate subjects for this study. The questionnaire consisted of four sections, the first section was about the intake of sweet snacks, the second was about the intake of sugar-sweetened beverages, the third was about liking for tapioca milk and the fourth elicits demographic information on the subjects. Inclusion criteria were as follows: (1) the weekly frequency of intake of sugar-sweetened beverages had to be four or more times, (2) the weekly frequency of intake of sweet snacks had to be two or more times, (3) those who like tapioca milk tea, (4) age from 20 to 24 years old without sickness. A total of 75 students met the conditions, and after an orientation the number of remaining students was 40. Two of them were excluded because their records were incomplete, and the final available number was 38 (16 males and 22 females; 15 and 23 were from the nutrition and non-nutrition departments, respectively).

Orientation

We held two orientations for this study to explain the purpose and implementation of the research methods. Participants were instructed in how to record their intake of sugar-sweetened beverages and sweet snacks. Through discussion, it was confirmed that subjects understood how to record their intake of sugar added foods and could fill out their records sheets without error.

Ethics of human subject participation: This study was approved by the ethical committee of National Cheng Kung University Governance Framework for Human Research Ethics please add number of approval (No. 104-029). The participants were informed in detail about the purpose, the advantages and disadvantages of this study, and their rights and obligations pertaining to their lifestyle. Informed consent was obtained from all the participants.

Study design

This study was conducted by cross-over design. We matched pairs of subjects by sex, age, and department, randomly divided into Group A and B. Each having 20 people, and were given either 500 mL tapioca milk tea or no tapioca milk tea for the first week. After a one week-long washout period, the subjects received the opposite test for another week. Each period was 1 week with a 1 week washout between the periods, was with or without tapioca milk tea, and freely allowed other beverages. The duration of study was three weeks. Tapioca milk tea of 500 mL is consisted of fructose 2.55 g, glucose 2.55 g, sucrose 18.65 g. All subjects had to keep a record of sugar added foods for each week by filling out their record sheets and took photographs whenever they drank sugar-sweetened beverages or ate sweet snacks during intervention.

Estimation of sweet food intake

When the subjects started the study, they had to write a sugar added food record for each week (with or without tapioca milk tea) and photograph whenever they drank sugar-sweetened beverages or ate sweet snacks. The records were confirmed by the researcher the next day. In order to estimate weights of beverages and snacks intake we have four methods: (1) weighing method (When the subjects consumed sugar-sweetened or sweet snacks, they put the food on a scales to check the weight of sweet food), (2) food model (subjects were instructed to report food record and we used food model to estimate intakes of sugar-sweetened beverage or sweet snacks), (3) use credit card for estimating size (before subjects consumed sugar-sweetened beverages or sweet snacks, they put a standard-size credit card next to it and took a photograph), (4) food label for estimating weight (if it had the nutrition facts on the label they could read the information and write the weight of what they ate or drank).

Calculation of sugar intake

The Taiwan sugar composition table "Development of a food composition database of refined monosaccharide and disaccharides in snacks, desserts, and beverages" was used (20). In this study, we estimated the total daily intake of sugar for each week with or without tapioca milk tea. If the intake of sweet snacks and sugar-sweetened beverages was not in this analysis table, the package label was used as a reference to calculate the intake of refined sugars.

Physical measurement

We did four times measurements before and after studies in each period. Height and weight were measured to one decimal point. We also used *In body 720 BODY COMPOSITION ANALYZER* (Seoul, South Korea products) to measure a subject's body composition.

Statistical analysis

Data were carried out with SPSS (version 18.0) statistical software. Data were assessed by paired *t*-test and *p* values less than 0.05 were considered statistically significant.

RESULTS

Table 1 shows the body characteristics of the subjects by gender (n=38, male 16, female 22).

Table 1. Body Characteristic of the subjects by gender

| | Body characteristics of the subjects by gender | | | |
|-------------|--|------|-------------|-----|
| | Male n=16 | | Female n=22 | |
| | mean | SD | mean | SD |
| Height (cm) | 173.5 | 6.3 | 158.9 | 6.3 |
| Weight (kg) | 73.1 | 12.0 | 56.3 | 8.9 |
| BMI* | 24.4 | 4.3 | 22.4 | 3.9 |
| Age | 21.1 | 0.9 | 21.1 | 1.0 |

*Body Mass Index = weight in kg / height in m²

Table 2 presents sugar intakes in the period with or without tapioca milk tea by gender and percentages of each sugar against total intake of all subjects in the week with or without tapioca milk tea (TM and NTM, respectively). All the sugar intakes were not significantly different between the two periods ($p > 0.05$) except that the sucrose intake of females was higher in TM than in NTM. The intake of glucose + fructose increased in the week without tapioca milk tea, about 44% more than the week of consuming tapioca milk tea, when it was about 38%. In the week with tapioca milk tea total sugar intake was 58.4g/ day (glucose 21%, fructose 17%, sucrose 60%, lactose 2%). In the week without tapioca milk tea total sugar intake was 56.5 g/ day (glucose 25%, fructose 19%, sucrose 53%, lactose 3%).

Fig. 1 shows daily and mean sugar intakes for the weeks with or without tapioca milk tea. Statistical differences between days with and without tapioca milk tea were not observed ($p > 0.05$). The average sugar intakes with or without tapioca milk tea were similar, and in the week with tapioca milk tea period intake was 58.4 ± 23.2 g/day, while in the week without tapioca milk tea period it was 56.5 ± 22.2 g/day.

Table 2. Sugar intakes in the period with or without tapioca milk tea by gender

| | Sugar intakes in the period by gender and percentage of sugar intake against total intake with or without tapioca milk tea | | | | | | | | | |
|---------------|--|------|------|------|-------------|------|------|------|--------------|-----|
| | Male n=16 | | | | Female n=22 | | | | All Subjects | |
| | TM* | | NTM† | | TM | | NTM | | TM | NTM |
| | mean | SD | mean | SD | mean | SD | Mean | SD | % | % |
| Sugar Intakes | | | | | | | | | | |
| Glucose | 13.8 | 11.3 | 15.6 | 11.5 | 10.4 | 5.8 | 11.8 | 7.4 | 21 | 25 |
| Fructose | 11.6 | 8.6 | 11.6 | 8.2 | 8.2 | 4.2 | 8.8 | 5.7 | 17 | 19 |
| Sucrose | 36.1 | 14.2 | 30.8 | 14.4 | 32.1 | 8.8 | 25.5 | 15.5 | 60 | 53 |
| Lactose | 0.9 | 1.3 | 1.5 | 1.4 | 1.3 | 1.7 | 1.6 | 1.7 | 2 | 3 |
| Total | 64.1 | 28.9 | 62.9 | 23.9 | 54.2 | 17.5 | 51.8 | 20.3 | 100 | 100 |

*TM, Tapioca Milk Tea (With Tapioca Milk Tea)

†NTM, No Tapioca Milk Tea (Without Tapioca Milk Tea)

Bold indicates the significant difference between the week with TM and the week with NTM analyzed by paired t-test, respectively ($p < 0.05$)

Fig. 2 shows the daily sugar intake of individuals in males (a) and females (b) with and without tapioca milk tea and the statistical difference between the two periods. Although there were 16 male subjects, here we show only 9. Only two of the 16 subjects had different sugar intakes in the two periods ($p < 0.05$). There were 11 females with a total of 22. All the subjects took a similar amount of sugar in the two periods ($p > 0.05$).

Fig. 3 shows the total percentages of sugar intake from sugar-sweetened beverages and sweet snacks. In the week without tapioca milk tea, subjects consumed more than 85% of their sugar from beverages. The sugar intake in the week with tapioca milk tea from sugar-sweetened beverages was 90% (52.6 g), and from sweet snacks was about 10% (5.8 g). The sugar intake in the week without tapioca milk tea from sugar-sweetened beverages was 86% (48.6 g), from sweet snacks was about 14% (7.9 g). On the middle part, it shows the contribution of major beverage groups to sugar intake

from sugar-sweetened beverages as follows. In the week with tapioca milk tea sugars from milk tea contributed about 55% (28.9 g) and tea and soft drinks about 21% (11 g) and 11% (5.8 g), respectively. These 3 items contributed about 87% of the sugar intake from beverages. In the week without tapioca milk tea sugars from tea contributed about 42% (20.4 g) and milk tea and soft drinks about 20% (9.7 g) and 14% (6.8 g), respectively. These 3 items contributed about 76% of the sugar intake from beverages. In the week without tapioca milk tea, the percentage of sugar intake from tea increased to 42%. On the left part, it shows the contribution of major foods to sugar intake from sweet snacks. In the week with tapioca milk tea, ice products contributed about 26%, cake about 18% and bread and cookies about 17% and 9%, respectively. These 4 items contributed about 70% of the sugar intake from sweet snacks. In the week without tapioca milk tea, sugars from cake contributed about 21%, from ice products about 17% and from bread and cookies about 14%

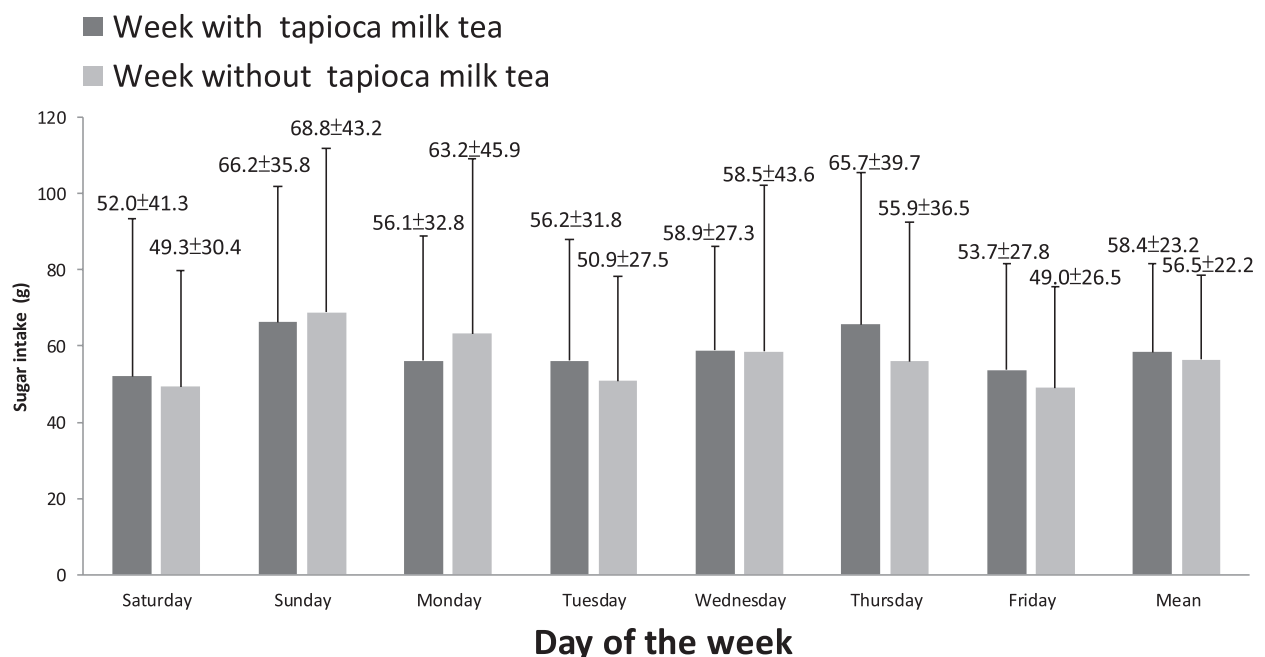


Fig 1. Daily sugar intakes (mean ± SD) of a week with or without tapioca milk tea (n=38, 16 males and 22 females).

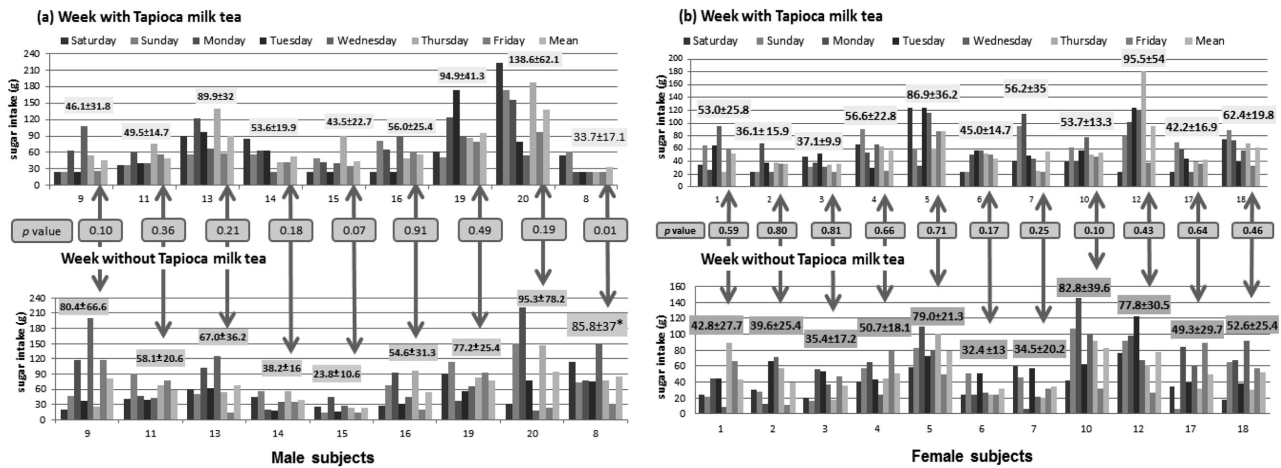


Fig 2. Daily sugar intakes (mean \pm SD) of individuals in males (a) and females (b) with and without tapioca milk tea.

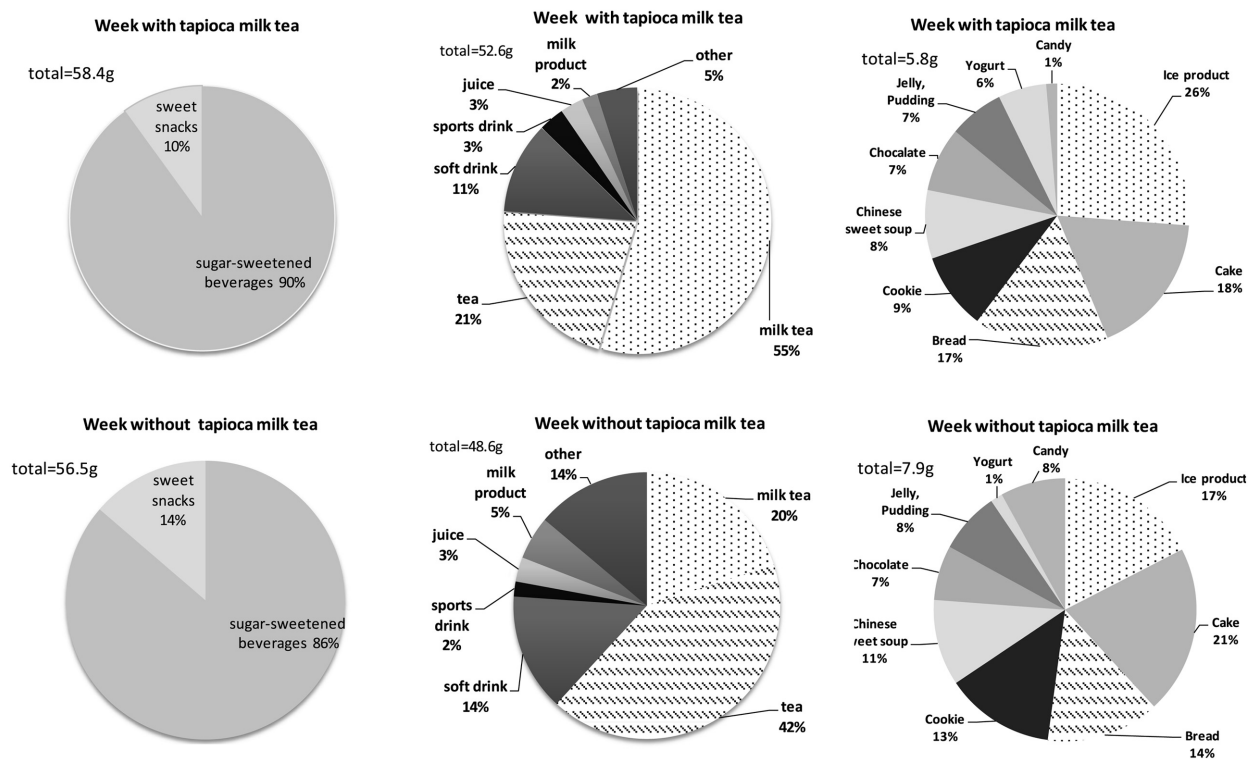


Fig 3. Percentages of sugar intake from sugar-sweetened beverages and sweet snacks, that were in weeks with (upper) or without (below) tapioca milk tea were shown at the left. Contribution of various food groups to either sugar-sweetened beverages or sweet snacks was shown as followed.

and 13%, respectively. These 4 items contributed about 65% of the sugar intake from sweet snacks, respectively.

DISCUSSION

This study was conducted by cross-over design. Subjects were match-paired by sex, age, and department and were randomly

divided into two groups. We found in this study that average sugar intakes from sugar-sweetened beverages and sweet snacks were similar with or without tapioca milk tea, being 58.4 ± 23.2 g/day and 56.5 ± 22.2 g/day, respectively ($p > 0.05$). Even with limited intake of tapioca milk tea, the subjects took the same amount of added sugar from other sugar-sweetened beverages and sweet snacks, suggesting that an established sugar intake level is hard to change. Excessive sugar intake can lead to health problems (6-18),

and former U.S. President Bill Clinton proposed a plan to stop the sale of cola and other sugar-sweetened beverages in public elementary schools (19). However, our present results proved that restriction of tapioca milk tea showed no substantial benefit in reducing sugar intake.

Dietary habits may play an important role because once it is established, it is difficult to change. Socio-psychological and environmental factors have an effect on changing eating behavior (21). For example, Japanese salt intake is one of the highest in the world and still many people suffer from hypertension, stroke, heart disease, even stomach cancer (22-24). For these reasons, Japanese have been trying to reduce salt intake for many years. However, in 2013 it was still 9.8g (25). WHO recommends an intake less than 5 g (26). Average intake by Americans is about 8.5 g (27) and they are trying to reduce it to less than 6 g (28). Death rate from stroke and stomach cancer is higher in Japan than in the US (29). Similar habits are seen in the high fat and sugar intake of Americans and many other nations. From these facts, our hypothesis would seem to be correct. Our present results also suggest that the Clinton strategy to limit high sugar soft drinks and juices maybe ineffective.

The present result also suggests that to change the behavior, we have to form good habits before bad ones are established. From reports by us and others (30), sugar intake of preschool children (2-5 y) was 13.0 g/day at 2 y, about 19.2 g/day at 3 y, about 31.6 g/day at 4 y, about 29.6 g/day at 5y (30) and 51.6 g at 7-12 y. If we express these intakes by percentage against total energy intake (reported by the Nutrition and Health Survey in Taiwan (NAHSIT)), they were 5% (2 y), 6%(3 y), 9%(4 y), 8%(5 y), 10.3%(7, 10, 12 y), and 10.9% (20-24 y), respectively. These results indicate that after 4 years old, the percentage of energy from sugar becomes almost 10% and is maintained, indicating that the habit of high sugar intake is already established at 4 years old.

WHO and American Guideline recommended that healthy eating patterns limits added sugars to less than 10% of calories per day. However, WHO recommended further reduction to 5% for better health benefits (31). The young Taiwanese in this study obtain approximately 10.9% of their total intake from added sugars as expressed by percentage against total energy intake reported by NAHSIT (32). Recent American analyses indicate that 18-34 years old adults obtain approximately 16.3% of their total intake from added sugars (35).

There are reports about sugar intake from various countries (g/day) : United Kingdom 85(33), South African 70(34), American adults of 18-34y old 92.3(35) and Japanese 24.7(30). Sugars intake in this study is lower than that of American 18-34 years old adults, 92.3g/day between the years 2007 to 2008(35), but more than Japanese children 24.7 g/day(30). We can see that sugar intake in Taiwan was between the United States and Japan.

In the present result, whether tapioca milk tea was limited or not, there was still 85% of sugar intake from sugar-sweetened beverages. Sugar intake in the week with tapioca milk tea from sugar-sweetened beverages was 90% (52.6 g), and in the week without tapioca milk tea was 86% (48.6 g), milk tea was the major beverage for sugar intake. In the United States, more than 59% (54 g) of sugar intake was from sweetened beverages in 18-34 years old adults, and soft drinks were the leading contributor of sugar intake for this age group (33), but in Japanese children only 25% (6.2g) was from sugar-sweetened beverages (30). In this study, sugar intake from sweet snacks was 10% (5.8 g with tapioca milk tea) and 14% (7.9 g without tapioca milk tea) in Taiwan, 41% (38 g) in United States, 75% (18.5 g) in Japan. This means that in the United States, sugar intake from both beverages and snacks is higher than in Taiwan or Japan. In Japan, although the sweet snacks intake is higher than in Taiwan, because of low intake of sugar-sweetened beverages, the total sugar intake is only half of Taiwan's. These data show that Taiwanese take most of their sugar from beverages and a

little from snacks. However, as discussed above, it is not easy to limit beverages and this again shows the importance of establishing the habit of low sugar intake from beverages from childhood. In Taiwan, kindergartens provide sweet snacks or sugar-sweetened beverages once or twice every day. From the results, we recommend that before children establish habits of eating sweet foods, when the child wants to eat something, maybe choosing unsweetened natural food can be established as a better habit.

According to the results, during the week with tapioca milk tea, sugar intake from milk tea was about 28.9 g. We used Nutrition and Health Survey in Taiwan (NAHSIT) data, which show a daily energy intake for adults (19-30 y) of about 2100 kcal/day (24), the milk tea accounted for 5.7% (28.9 g) of total intake, similar to soft drinks in United States, where total energy intake from soft drinks is 6.4% (36.5g) (27). So we can say the prevalence of American soft drinks and Taiwan milk tea is about the same.

We know that most of the sugar-sweetened beverages contain isomerized sugar, also known as high-fructose corn syrup. It is produced by the hydrolysis of corn starch and other starches and is cheaper than sucrose. It is in soluble form and is usually used in beverages. In recent years, high-fructose corn has been shown to lead to many health problems (6-18), and Taiwan has begun to pay attention to this problem. In Taiwan, there are many beverage stores, these stores have begun to reduce the use of isomerized sugar, and instead use sucrose.

The contribution of each sugar to the total sugar intake (about 58.4 g) for the week with tapioca milk tea in the present study was 60% (35 g) for sucrose, 21% (12.3 g) for glucose, 17% (9.9 g) for fructose and 2% (1.2 g) for lactose (Table 2). From the data shown in Fig. 3, sugar intake from beverages was 90% (52.6 g). These results indicate that fructose and glucose (total 38%) were mainly from beverages, and some drink beverage stores are using sucrose in beverages, so sugar-sweetened beverages also contain sucrose (total 60%).

Biochemical pathways of glucose and fructose are different and have different physiological effects. For example, fructose increases blood triglyceride concentration more than glucose (8-11), and may lead to an increase in body weight (6-8, 12-16), and to diabetes (16-18). Therefore, we need to recognize the intake of carbohydrate sources in our daily lives and to understand their impact on health.

Nutritional surveys may have overestimated or underestimated the intake ; in order to prevent it, we used several means : weighing method, food models, standard cards (use of credit card for estimating quantity), and use of food labels for estimating weight, which were our four methods to identify the intake.

This study was conducted in summer. In this season, sugar intake from beverages is thought to be usually higher than in other seasons, because people drink more cold sweet beverages. However, Taiwanese also have hot sweet beverages in winter, which decreases the overestimation or underestimation problem. Taiwanese young people like to drink sugar-sweetened beverages, so we may speculate that this is associated with the environment and habits.

In conclusion, Taiwanese have high sugar intake, especially from beverages, perhaps because of childhood habits. Nutrition education should be directed to all and the government and the general public must be in agreement in order to avoid health problems caused by bad habits.

DISCLOSURE STATEMENTS

Financial Support

No specific grants for this research.

Conflict of interest

The authors declare no conflict of interest. We declare that all authors have approved of the manuscript to submit to The Journal of Medical Investigation. We also declared that the contents of the manuscript have not been previously published and are not currently submitted elsewhere.

Authorship

P.Y.L. and T.C.C. contributed in designing the protocol, collecting data, analyzing data, and writing the article. F.Y.L. contributed in analyzing data and writing the article. J.Y.D. and W.L.C. contributed in collecting data. I.K. and H.T. contributed in analyzing data and writing the article. S.Y. gave advice on designing the study, interpreting the results, and writing the article.

Ethics of human subject participation

This study was approved by the ethical committee of National Cheng Kung University Governance Framework for Human Research Ethics please add number of approval (No. 104-029). The participants were informed in detail about the purpose, the advantages and disadvantages of this study, and their rights and obligations pertaining to their lifestyle. Informed consent was obtained from all the participants.

ACKNOWLEDGEMENTS

The authors would like to thank the subjects for their cooperation in participating in this study. We are also grateful to Fooyin University and all the co-researchers and advisors for our study and Dr. Andrew Durkin, Professor Emeritus of Indiana University for editing English. This study was supported by US-Japan Medical Science Program.

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